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Research Article

Using bioacoustics to assess the impact of evergreen invasive plants on bird communities in Wales, United Kingdom

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Abstract

Invasive alien species are one of the major drivers of biodiversity loss, with birds amongst the most vulnerable taxa affected by their impacts. However, potential impacts on bird communities have rarely been investigated, particularly through bioacoustic monitoring and citizen-science approaches. Here, we present a pilot study testing the feasibility of using bioacoustic monitoring, supported by citizen scientists, to explore how the formation of an evergreen shrub layer of invasive alien plants (*Rhododendron ponticum* and *Prunus laurocerasus)* may influence bird communities in broadleaved woodlands in Wales, United Kingdom. We trained volunteer citizen scientists on how to use passive acoustic monitoring devices (AudioMoths) to record bird calls. We then used the BirdNET software to identify bird species from 480 hours of audio recordings. A total of 28 bird species from 17 families were identified from the recordings. Overall, the frequency of bird calls did not differ between the control and invaded plots. However, there was significant difference in the frequency of bird calls based on their trophic niches, suggesting that birds respond in different ways to the presence of invasive alien plants. This pilot study shows that bioacoustic monitoring is an effective tool for investigating invasive species impacts and that it can be integrated with citizen science to assess how invasive evergreen shrubs influence bird communities.

Key words: AudioMoth, citizen science, community science, ecoacoustics, Europe, non-native species, sound recording, volunteers

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Introduction

Invasive alien species are one of the five major direct drivers of biodiversity decline (IPBES 2019), with alien species continuing to be introduced, spread and impacting on ecosystems and human well-being (Roy et al. 2024). Birds, recognised as bioindicators of ecosystem health due to their sensitivity to environmental changes (Kułaga and Budka 2019; Adekola et al. 2021a; Adekola et al. 2021b; Adekola 2022), are a particularly vulnerable group amongst the taxa affected by invasive alien species, with 74 global extinctions of species documented mainly caused by invasive alien predatory mammals or reptiles on islands (Bacher et al. 2023). Less attention has been given to the impacts of invasive alien plants on birds (Flanders et al. 2006). These impacts include structural changes in ecosystems caused, for example, in forests by dense shrub layers of *Lantana camara* (Aravind et al. 2010), *Ulex europaeus* (Amaya-Villarreal & Renjifo, 2010) or the perennial herbaceous plant *Heracleum sosnowskyi* (Grzędzicka & Reif, 2020) affecting

bird community compositions. Some bird species may benefit from the additional feed sources provided by some invasive alien plants and thus can facilitate their spread (Bitani et al. 2022). An example of this is the invasion of the waxbill *Estrilda astrild* in Europe, where populations have increased alongside the spread of invasive plant species that provide suitable food and habitat resources (Sullivan et al. 2015; Lucio-Puig et al. 2025), but seem nevertheless not to compete with native species (Cardoso and Reino 2018). Understanding such responses requires investigating the functional traits that mediate how bird species interact with altered habitats.

The integration of functional traits provides valuable insights into how ecological processes are structured and maintained. Functional traits represent species' characteristics that influence their ecological roles (Tobias et al. 2022), which are crucial for understanding how they respond to environmental changes. In birds, traits, such as foraging strategy and habitat preference, can provide information into how species adapt to or are affected by environmental pressures. For example, species with specialised feeding habits or habitat preferences are often more vulnerable to habitat alteration and invasive species than generalist species (McGill et al. 2006; Clavel et al. 2011). Consequently, analysing avian functional traits can provide an understanding of how invasive plants alter bird communities. While such ecological mechanisms are increasingly recognised, studying them effectively requires robust and scalable monitoring tools (Tobias et al. 2022). Bioacoustic approaches offer a powerful means of capturing types of species-specific vocal behaviour that reflect differences in community composition and functional guild structure, providing insights into how resource-use varies across habitats.

Recent advances in sound-based conservation technologies, such as passive acoustic monitoring (PAM), have facilitated rapid biodiversity assessments over broad spatial and temporal scales (Celis-Murillo et al. 2009). This advancement provides a less-intrusive, faster and cheaper method of collecting large acoustic datasets for biodiversity assessment (Sueur et al. 2008; Alcocer et al. 2022; Diaz et al. 2023; Quinn et al. 2023). Sound from the environment, usually collected by PAM devices, serves as a powerful and valuable data source for assessing the health of an ecosystem (Hill et al. 2019). Birds can be identified by their distinct vocalisations, making them a suitable model for acoustics studies (Gaspar et al. 2023). PAM is an effective method for studying bird communities and using sound recorders helps to overcome the logistical challenges associated with point count and line-transect surveys (Biffi et al. 2024; Bradfer-Lawrence et al. 2024; Kotian et al. 2024). Bioacoustics analyses focus on vocalising biodiversity in soundscapes by measuring variations in acoustic features through the application of various acoustic indices (Bradfer-Lawrence et al. 2019).

The availability of cost-effective and easy-to-use audio recording equipment, such as AudioMoths (Hill et al. 2019), has made it increasingly feasible to integrate passive acoustic monitoring into citizen-science projects. This is similar to how smartphone applications for species recording and identification have advanced biological recording with citizen science more than a decade ago (Howard et al. 2022). In this study, the citizen scientists deployed AudioMoth recorders themselves.

Here, we assess the impacts of evergreen invasive plants on birds in four woodlands in Wales, United Kingdom, using audio recordings collected by these volunteer citizen scientists in invaded and non-invaded control plots. To our knowledge, no previous study has used bioacoustics data to explore the impacts of invasive alien plants on birds. This pilot study therefore aims to test the feasibility of using bioacoustic monitoring to explore how invasive alien plants may influence bird communities.

Materials and methods

Study sites, data collection and bird species identification

The study focused on broadleaved woodlands invaded by non-native evergreen alien woody plants (*Rhododendron ponticum* and *Prunus laurocerasus*) forming dense shrub layers leading to structural changes in the invaded woodlands. *R. ponticum* is one of the invasive alien plants with the most severe impacts in Britain (Dehnen-Schmutz et al. 2004; Eschen et al. 2023), with well-documented impacts particular in woodlands, where it forms a dense shrub layer shading out native vegetation and preventing natural woodland regeneration (Casati et al. 2022). In Wales, Eryri National Park alone spent around £2.2 million between 2018 and 2024 to manage *R. ponticum* (personal communication, Gethin Davies 2024). Impacts of *P. laurocerasus* in woodlands are reported to be similar, but have been less well-documented (Dehnen-Schmutz et al. 2022). Given these shared structural characteristics, we explored their influence together on bird activities.

We recruited five volunteer citizen scientists through events run in collaboration with the North Wales Wildlife Trust for people interested in the management of invasive species. The volunteers suggested suitable sites close to where they lived and their site choices were discussed with the research team to ensure they met defined criteria before the recordings took place (Beason et al. 2020). The selected invaded plots were characterised by the presence of *R. ponticum* and/or *P. laurocerasus* covering more than 50% of the vegetation within a minimum 3 m × 3 m area surrounding the AudioMoth. Although site selection was led by volunteers, it reflects the ecological reality of invasive plants in Wales, where *R. ponticum* and *P. laurocerasus* occur in patchy, but locally dominant stands. This approach is also consistent in the broader project (Dehnen-Schmutz et al. 2025). We acknowledge, however, that this method of site selection, while practical and volunteer-driven, could introduce potential bias.

Control plots were chosen in an area of the same woodland where the invasive target species were not present and at an approximate minimum distance of 500 metres from the invaded plot to avoid overlap of bird calls (Winiarska et al. 2024), although there is no specific minimum distance that has been standardised between acoustic devices to avoid overlap of sounds as recording distance varies based on the location (Biffi et al. 2024).

The volunteers deployed AudioMoths (Hill et al. 2019) in the invaded and non-invaded control plots from late June to September 2023 (Table 1). Each AudioMoth was enclosed in an AudioMoth Waterproof Case and configured by the volunteers using the AudioMoth Configuration App (Hill et al. 2019; Prince et al. 2019) and following instructions provided by the research team. The AudioMoth was programmed at a sample rate of 192 kHz (Hill et al. 2019) and set to record in hourly intervals for a standardised duration of 6 hours each day (between 05:00 h and 08:00 h and 17:00 h and 20:00 h) to capture peak period of bird activities. One of the volunteers did not return any recordings, resulting in recordings from four sites. All recordings were reviewed by one of the authors (OA) and recordings affected by potential influences such as proximity to infrastructure, noise sources, nearby waterbodies or adverse weather conditions were identified and excluded. In total, the survey effort amounted to 480 hours of acoustic recordings across all sites. While Bradfer-Lawrence et al. (2019) recommended at least 120 hours of continuous

Table 1. Location and date of recordings at control and invaded plots across four woodlands in Wales between June and September 2023.

Location	Date of recording	What3words reference	Invasive species
Nercwys Forest	8–9 July 2023	curvy.regret.bolsters	*R. ponticum*
Nercwys Forest	8–9 July 2023	conspired.labels.painted	Control
Penllergare, Swansea	30 June-3 July 2023	pines.turned.metals	*R. ponticum*
Penllergare, Swansea	30 June-3 July 2023	marble.matter.card	Control
Wye Valley*	16–17 Aug. 2023	51°44'04.1"N, 2°41'44.4"W	*P. laurocerasus*
Wye Valley*	16–17 Aug. 2023	51°44'04.1"N, 2°41'44.4"W	Control
AberKenfig	20/22 Sept. 2023	index.turns.rabble	*R. ponticum*
AberKenfig	20/22 Sept. 2023	left.hunches.centuries	Control

*Rough location only, no What3words reference was taken.

recordings per site for broad soundscape categorisation, our study focused on comparisons of bird activities between invaded and non-invaded control plots, rather than full soundscape assessments. As such, shorter hours of recording at each site were deemed appropriate. Moreover, this study was designed as a pilot to test the feasibility of using citizen science in invasive species impact monitoring and relied heavily on the availability and commitment of trained volunteers. Consequently, it was necessary to make efficient use of limited time to coordinate deployments within the available time. These limitations are reflective of volunteer-led acoustic data collection and provide valuable insight into both the potential and the challenges of integrating acoustic monitoring into participatory approaches for biodiversity assessment.

Recordings in the invaded and non-invaded control plots at each site took place simultaneously to reduce biases and geographical references (what3words) were recorded for each site (except for Wye Valley, where coordinates were provided; Table 1). All audio-recordings from control and invaded plots can be found in the Environmental Information Data Centre (EIDC) repository (Dehnen-Schmutz and Adekola 2024).

We used the BirdNET software (Kahl et al. 2021; Bota et al. 2023), which applies machine-learning algorithms to identify bird species from audio recordings by analysing sound spectrographs (Biffi et al. 2024). BirdNET provides both species names and the frequency of calls per hour for each bird species. Species identifications generated by BirdNET were verified by one of the authors (OA) and some of the volunteers to confirm the accuracy of the automated classifications. Recordings of unidentified calls were discarded from the analysis.

To provide insights into how bird communities change due to the presence of invasive alien plants, we also classified birds identified, based on their trophic level (carnivore, herbivore or omnivore), trophic niche (granivore, invertivore, omnivore or vertivore) and primary lifestyle (generalist, insessorial or terrestrial) (cf. Tobias et al. (2022); Tables 2, 3). Trophic level refers to the species' position in the food chain, while trophic niche describes the specific dietary resources of the species. Exploring both trophic level and niche is important because, while trophic level provides a broad perspective of the species' contribution in energy transfer, trophic niche offers deeper insight into its resource use and ecological interactions (Tobias et al. 2022).

Table 2. Bird species detected and identified using BirdNET in control and invaded plots across four woodlands in Wales between June and September 2023, and their trophic level, niche and lifestyle (Tobias et al. 2022).

Order/ Family	Common Name	Scientific Name	Trophic Level	Trophic Niche	Primary Lifestyle
Columbiformes					
Columbidae	Stock Dove	*Columba oenas*	Herbivore	Omnivore	Terrestrial
Gruiformes					
Rallidae	Eurasian Moorhen	*Gallinula chloropus*	Omnivore	Omnivore	Terrestrial
Passeriformes					
Aegithalidae	Long-tailed Tit	*Aegithalos caudatus*	Carnivore	Invertivore	Insessorial
Certhiidae	Eurasian Treecreeper	*Certhia familiaris*	Omnivore	Invertivore	Insessorial
Corvidae	Eurasian Jackdaw	*Coloeus monedula*	Omnivore	Omnivore	Terrestrial
Corvidae	Eurasian Jay	*Garrulus glandarius*	Omnivore	Omnivore	Insessorial
Corvidae	Eurasian Magpie	*Pica pica*	Omnivore	Omnivore	Terrestrial
Fringillidae	Eurasian Bullfinch	*Pyrrhula pyrrhula*	Herbivore	Omnivore	Insessorial
Fringillidae	Eurasian Siskin	*Spinus spinus*	Herbivore	Granivore	Insessorial
Fringillidae	European Goldfinch	*Carduelis carduelis*	Herbivore	Granivore	Insessorial
Muscicapidae	Common Redstart	*Phoenicurus phoenicurus*	Carnivore	Invertivore	Insessorial
Muscicapidae	European Robin	*Erithacus rubecula*	Carnivore	Omnivore	Generalist
Muscicapidae	Spotted Flycatcher	*Muscicapa striata*	Carnivore	Invertivore	Insessorial
Paridae	Coal Tit	*Periparus ater*	Omnivore	Invertivore	Insessorial
Paridae	Eurasian Blue-tit	*Cyanistes caeruleus*	Omnivore	Invertivore	Insessorial
Paridae	Great Tit	*Parus major*	Omnivore	Invertivore	Insessorial
Phylloscopidae	Common Chiffchaff	*Phylloscopus collybita*	Carnivore	Invertivore	Insessorial
Prunellidae	Dunnock	*Prunella modularis*	Omnivore	Invertivore	Terrestrial
Regulidae	Goldcrest	*Regulus regulus*	Carnivore	Invertivore	Insessorial
Sittidae	Eurasian Nuthatch	*Sitta europaea*	Carnivore	Invertivore	Insessorial
Sylviidae	Eurasian Blackcap	*Sylvia atricapilla*	Omnivore	Omnivore	Insessorial
Troglodytidae	Eurasian Wren	*Troglodytes troglodytes*	Carnivore	Invertivore	Insessorial
Turdidae	Eurasian Blackbird	*Turdus merula*	Omnivore	Omnivore	Generalist
Turdidae	Song Thrush	*Turdus philomelos*	Omnivore	Invertivore	Generalist
Piciformes					
Picidae	Great-spotted Woodpecker	*Dendrocopos major*	Omnivore	Omnivore	Insessorial
Picidae	Lesser-spotted Woodpecker	*Dryobates minor*	Carnivore	Invertivore	Insessorial
Strigiformes					
Strigidae	Tawny Owl	*Strix aluco*	Carnivore	Vertivore	Insessorial

Common Redstart *Phoenicurus phoenicurus* and Eurasian Jackdaw *Coloeus monedula* were not recorded in the control plot, while Stock Dove *Columba oenas*, Eurasian Moorhen *Gallinula chloropus* and European Goldfinch *Carduelis carduelis* were not recorded in invaded plot.

Statistical analyses

All statistical analyses were performed in the R statistical environment (R Core Team 2024). Bird vocalisations were identified and classified to species level using BirdNET Analyzer (Kahl et al. 2021). From the output, we extracted the number of bird species identified and the total number of calls detected per recording (call frequency). These data were aggregated at the plot level and used to compare differences in call frequency between control and invaded sites, as well as across different functional traits, such as trophic niche, trophic level and primary lifestyle (Tables 2, 3).

Table 3. Functional traits of bird species detected and identified using BirdNET in control and invaded plots across four woodlands in Wales between June and September 2023.

Functional trait	Frequency of bird calls	% of bird calls
Trophic level		
Carnivore	287	53
Herbivore	41	7
Omnivore	217	40
Trophic niche		
Granivore	24	4
Invertivore	359	66
Omnivore	156	29
Vertivore	6	1
Primary lifestyle		
Generalist	117	22
Insessorial	405	74
Terrestrial	23	4

We analysed variation in call frequency across plots and functional traits using generalised linear mixed models (GLMMs; Brooks et al. (2017)). An initial Poisson GLMM fitted with "lme4" (Brooks et al. 2017) showed strong overdispersion, so we refitted the models using a negative binomial error structure using "glmmTMB" (Brooks et al. 2017), which eliminated overdispersion and improved model fit. To evaluate the robustness of model selection, we used "MuMIn" (Brooks et al. 2017) to rank candidate models derived from a global model and automated model selection using AICc. This approach identified four top-ranked models within ΔAICc ≤ 2 (Table 4). The best model (model 4) included an interaction between plot type and trophic niche, as well as other predictors such as trophic level and primary lifestyle, with site included as a random factor (Table 4).

To interpret the fixed effects and interactions, we estimated marginal means using "emmeans" (Lenth 2020) on the response scale and pairwise contrasts were calculated between plots within each functional trait category. These contrasts were restricted *a priori* and interpreted descriptively (Table 5). We further evaluated the relative importance of predictors and interaction terms using model and Akaike weights and assessed the overall effects using Type II Wald χ^2 ANOVA on model 4 (Table 6). Predicted means and their standard errors were extracted and visualised as bar charts using "ggplot2" (Wickham 2016).

Table 4. Reduced set of candidate negative binomial mixed-effects models retained following *MuMIn* automated model selection from a global model. Only models within ΔAICc ≤ 2 were retained. Site was included as a random factor in all models. The best-fitting model (model 4) is shown in bold.

Model	Fixed effects	AICc	ΔAICc	Weight
Model 1	plot + niche + lifestyle	3936.3	1.66	0.168
Model 2	plot + niche + level + plot × lifestyle	3936.1	1.50	0.182
Model 3	plot + niche + level + lifestyle + plot × niche + plot × lifestyle	3935.4	0.75	0.265
Model 4	**plot + niche + level + lifestyle + plot × niche**	**3934.6**	**0.00**	**0.385**

Table 5. Estimated marginal means (± SE) and control–invaded contrasts for trophic niche, trophic level and primary lifestyle. Significant effects ($p < 0.01$) in bold.

Functional traits	Plot	EMM ± SE	p-value
Trophic niche			
Granivore	Control	5.80 ± 3.02	0.51
Granivore	Invaded	3.96 ± 2.30	
Invertivore	Control	6.37 ± 1.74	0.05
Invertivore	Invaded	4.87 ± 1.34	
Omnivore	**Control**	**3.95 ± 1.01**	**<0.001**
Omnivore	**Invaded**	**8.49 ± 2.40**	
Vertivore	Control	0.94 ± 0.72	0.88
Vertivore	Invaded	1.13 ± 1.18	
Trophic level			
Carnivore	Control	9.20 ± 3.12	0.83
Carnivore	Invaded	9.91 ± 3.74	
Herbivore	Control	1.22 ± 0.50	0.83
Herbivore	Invaded	1.32 ± 0.60	
Omnivore	Control	3.58 ± 1.15	0.83
Omnivore	Invaded	3.85 ± 1.43	
Primary lifestyle			
Generalist	Control	5.60 ± 1.81	0.83
Generalist	Invaded	6.02 ± 2.20	
Insessorial	Control	4.26 ± 1.16	0.83
Insessorial	Invaded	4.59 ± 1.53	
Terrestrial	Control	1.69 ± 0.70	0.83
Terrestrial	Invaded	1.82 ± 0.83	

Results

Bird species and call frequency between plots and functional traits

Plot-type effects

A total of 28 bird species from 17 families and five orders were identified from the recordings (Table 2). Species diversity was similar between control (26 species) and invaded plots (25 species). Overall, call frequency did not differ between the control and invaded plots ($\chi^2 = < 0.01$, df = 1, $p = 0.98$; Table 6).

Table 6. Type II analysis of deviance (Wald χ^2 tests) for the best-supported GLMM model (model 4). Significance effect: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; · $p < 0.1$).

Predictor	df	χ^2	p-value
Trophic level	2	51.08	< 0.001***
Primary lifestyle	2	10.91	0.004**
Trophic niche	3	7.32	0.062
Plot type	1	< 0.01	0.980
Trophic niche × Plot type	3	15.50	< 0.001***

Plot type and trophic niche

Trophic niche was the only functional trait showing a significant difference in call frequency between control and invaded plots (Table 5). Estimated marginal means indicated that omnivores produced more than twice as many calls in invaded plots (8.49 ± 2.40) than in control plots (3.95 ± 1.01, $p < 0.001$; Table 5, Fig. 1). This pattern corresponds with the plot × niche interaction ($\chi^2 = 15.50$, df = 3, $p < 0.001$; Table 6).

Other trophic niches did not show clear differences between plot types. Although, invertivores showed a noticeable difference in call frequency between plots (control: 6.37 ± 1.74 vs. invaded: 4.87 ± 1.34), but quite marginal ($p = 0.05$; Table 5, Fig. 1). In contrast, call frequencies of granivores (control: 5.80 ± 3.02 vs. invaded: 3.96 ± 2.30; $p = 0.51$) and vertivores (control: 0.94 ± 0.72 vs. invaded: 1.13 ± 1.18; $p = 0.88$) did not differ between plots (Table 5, Fig. 1).

Plot type and trophic level

Call frequencies did not differ between control and invaded plots for any trophic level (Table 5, Fig. 2). Estimated marginal means showed similar values across plots for carnivores (control: 9.20 ± 3.12 vs. invaded: 9.91 ± 3.74; $p = 0.83$), herbivores (control: 1.22 ± 0.50 vs. invaded: 1.32 ± 0.60; $p = 0.83$) and omnivores (control: 3.58 ± 1.15 vs. invaded: 3.85 ± 1.43; $p = 0.83$) (Table 5, Fig. 2).

Plot type and primary lifestyle

As with trophic level, call frequencies did not differ between control and invaded plots for any primary lifestyle (Table 5, Fig. 3). Estimated means did not show clear

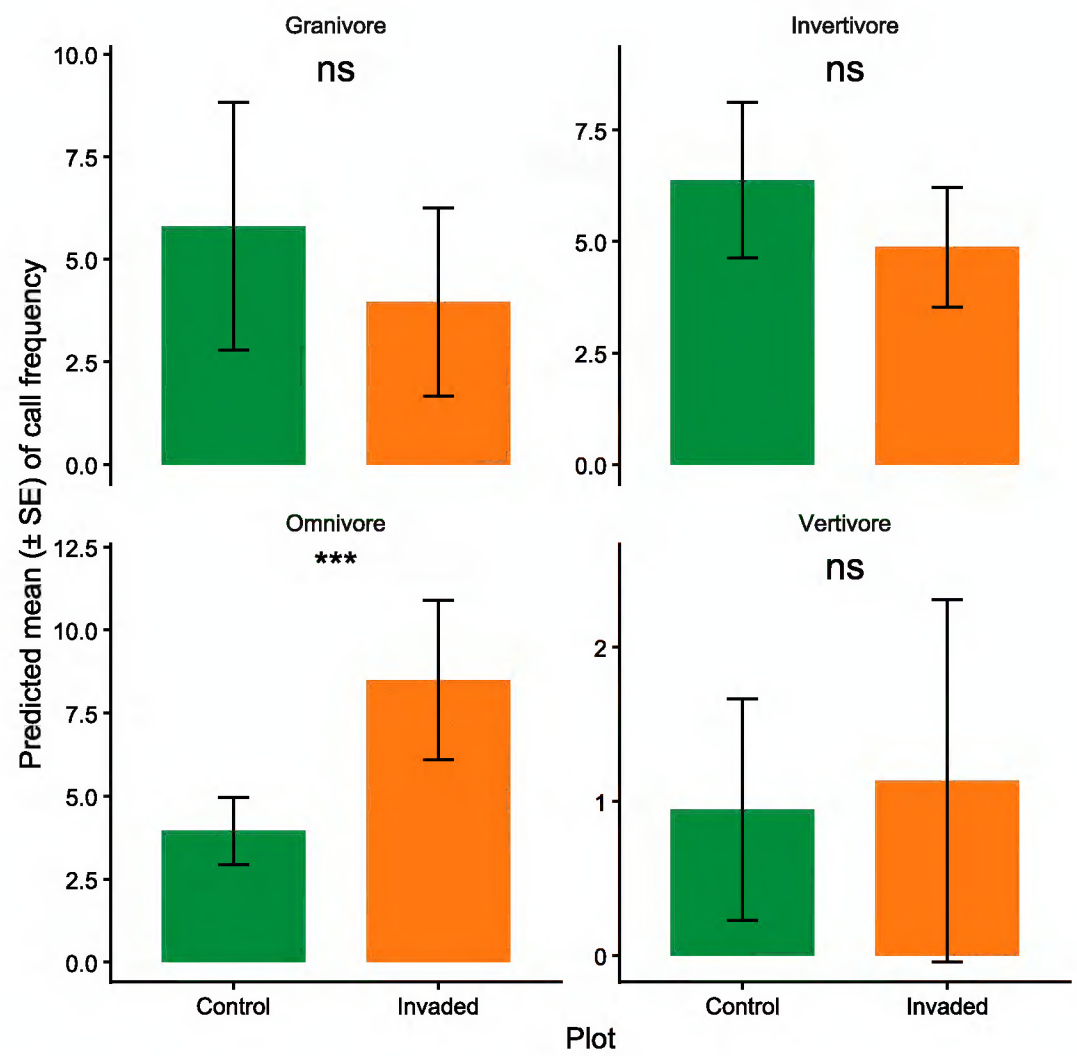

Figure 1. Predicted mean bird call frequency (± SE) for each trophic niche in control and invaded plots across four woodlands in Wales from June to September 2023 (***: $p < 0.001$; ns: not significant).

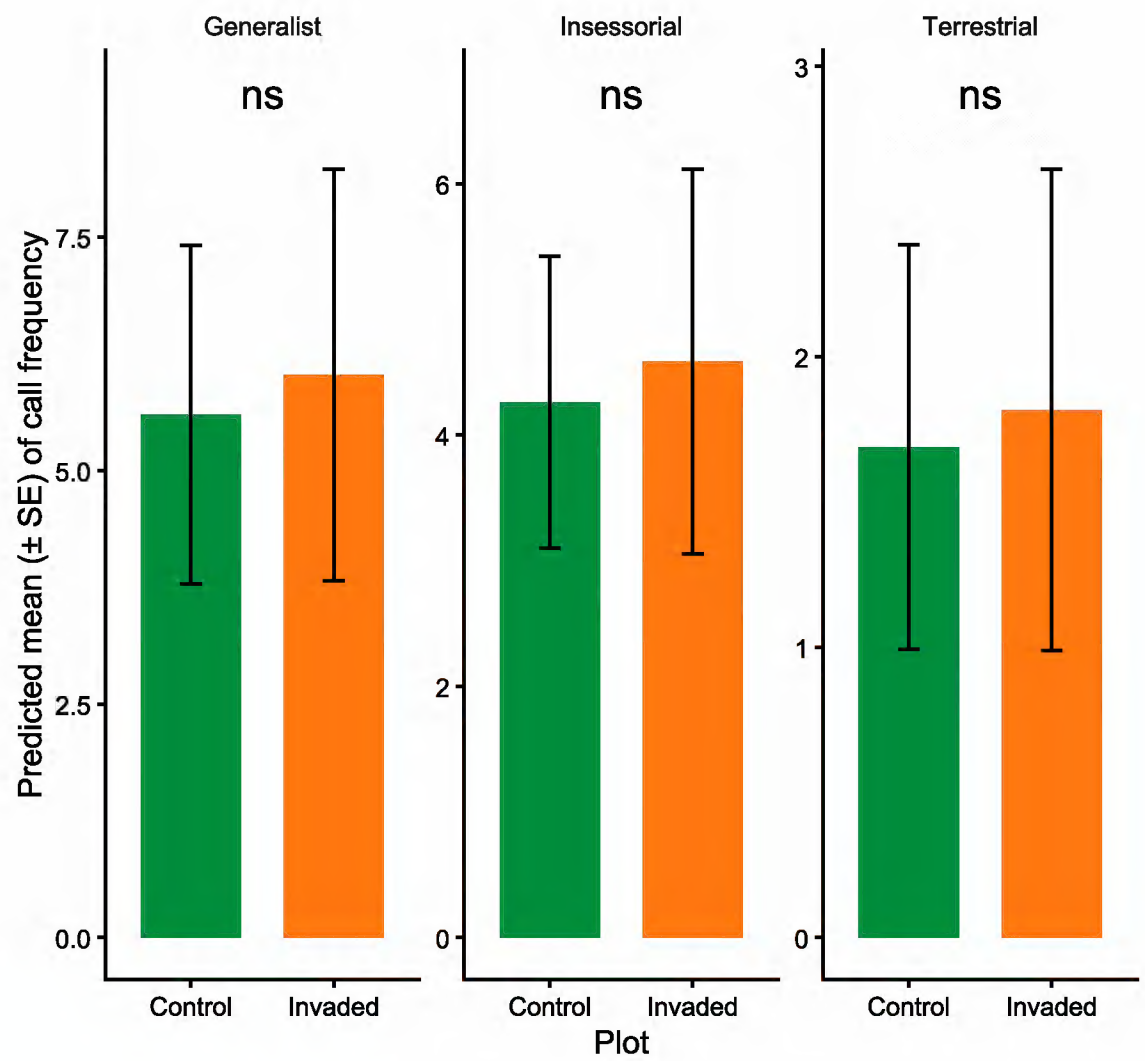

Figure 2. Predicted mean bird call frequency (± SE) for each trophic level in control and invaded plots across four woodlands in Wales from June to September 2023 (ns: not significant).

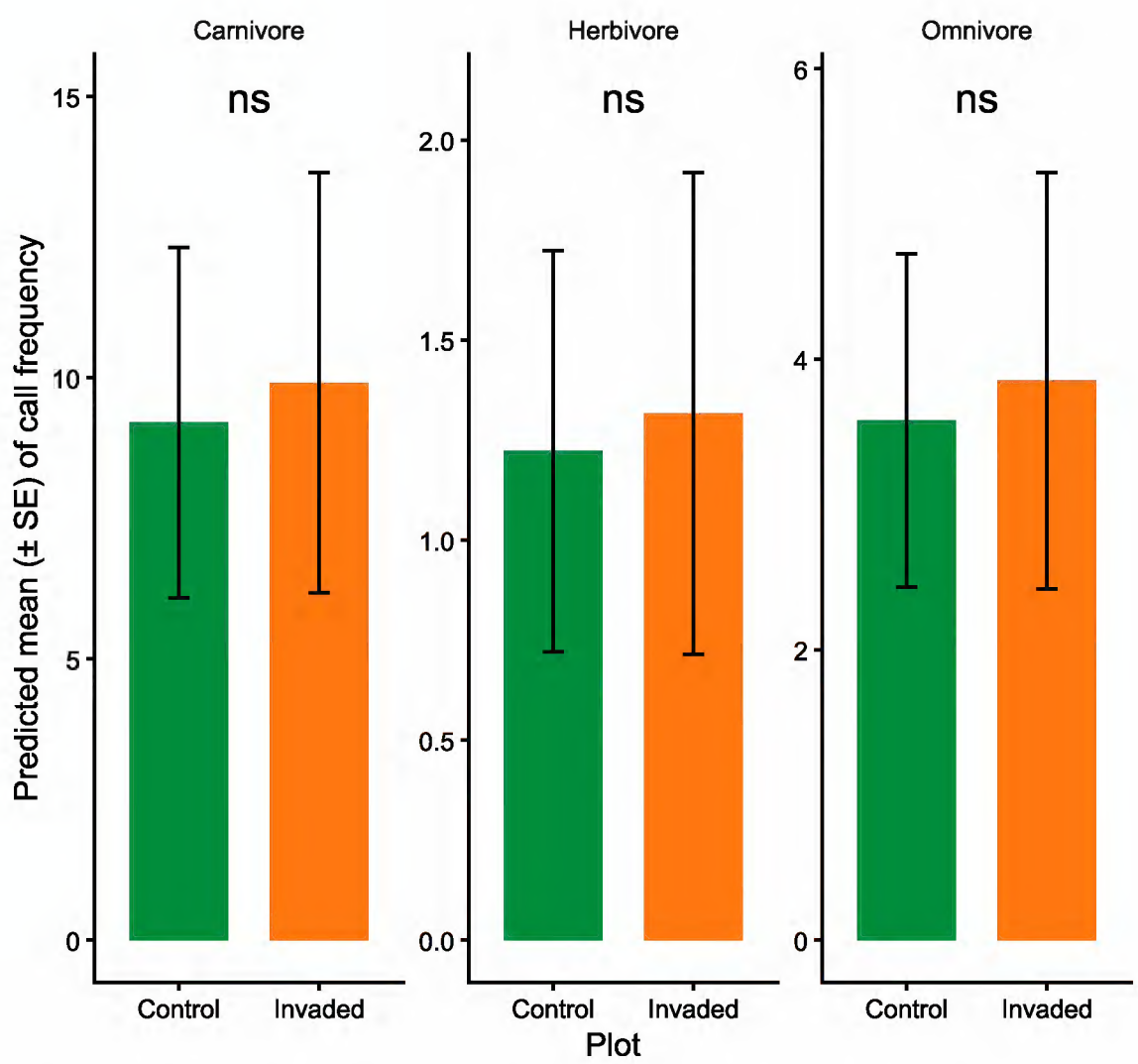

Figure 3. Predicted mean bird call frequency (± SE) for each primary lifestyle in control and invaded plots across four woodlands in Wales from June to September 2023 (ns: not significant).

differences across plot types for generalist (control: 5.60 ± 1.81 vs. invaded: 6.02 ± 2.20; p = 0.83), insessorial (control: 4.26 ± 1.16 vs. invaded: 4.59 ± 1.53; p = 0.83) and terrestrial species (control: 1.69 ± 0.70 vs. invaded: 1.82 ± 0.83; p = 0.83).

Citizen-science engagement in data collection

Our study trialled the engagement of citizen scientists in using the PAM device for data collection as part of a wider project exploring the approach for recording impacts of invasive species (Dehnen-Schmutz et al. 2025). We observed strong interest in the audio-recording technology at the volunteer events; however, due to the complexity of the tasks involved, the number of participants committing to the fieldwork was limited and not all were able to return recordings.

Discussion

Although overall species diversity and call frequency did not differ between control and invaded plots, our results reveal important functional-trait differences in how species respond to the invasive evergreen shrubs *R. ponticum* and *P. laurocerasus*. While the broader bird community suggests that the presence of invasive evergreen shrubs did not alter the broad structure of the bird community, clear differences emerged across trophic niches.

Omnivores showed increased call frequencies in invaded plots, suggesting they may benefit from the altered structure or resources provided by invasive plants. Omnivorous birds can benefit from wide variety of food resources available in invaded habitats, potentially increasing feeding opportunities for them. In the same vein, the higher frequency of calls could, therefore, suggest increased activities linked to foraging within the invaded plots. This is consistent with findings by Aravind et al. (2010) who reported that increase in *Lantana* density resulted in increase in the number of frugivorous birds. Hilje et al. (2017) also found that Liana abundance is linked to avian acoustic community in tropical dry forests. Furthermore, the presence of *R. ponticum* may indirectly affect avian foraging dynamics by altering the availability of rodents (Malo et al. 2013).

In contrast, no such plot-specific differences occurred in other groups within trophic niches, indicating that these groups did not alter their acoustic activity in relation to invasion. Yet, invertivores showed a slight, but modest decrease in call frequency within the invaded plot, which may suggest reduced insect availability associated with the presence of invasive evergreen shrubs, a pattern consistent with studies showing that invasive plants can negatively affect invertebrate resources and insectivorous bird activity (Amaya-Villarreal and Renjifo 2010; Bitani et al. 2022). Granivores and vertivores, on the other hand, showed no differences in call frequency between plots, suggesting that these groups may be less affected by the presence of invasive shrubs (Amaya-Villarreal and Renjifo 2010; Aravind et al. 2010).

We also found no clear differences in call frequency across control and invaded plots for trophic level and primary lifestyle, suggesting that these functional traits may be relatively capable of coping with the structural and resource changes imposed by invasive evergreen shrubs. Grzędzicka and Reif (2020) also reported that the presence of *Heracleum sosnowskyi* (Sosnowsky's hogweed) differently affected various foraging guilds of birds. Overall, our results highlight that invasive plants may not affect bird communities the same way.

Our findings highlight both the potential and the limitations of using citizen scientists to collect bioacoustic data on the impacts of invasive plants. Although initial involvement and engagement during outreach events was high, with

many volunteers expressing interest, this interest did not translate into sustained participation. This is consistent with the pattern reported in the broader project (Dehnen-Schmutz et al. 2025). Despite these constraints, we believe that citizen science has potential to support data collection for impact assessments. Future projects wanting to use this approach to achieve larger sample sizes should take into account the high level of essential training and continued engagement with volunteers which is essential for the selection of sites and setting up of equipment, particular if wanting to realise longer recording times and more sample sites which necessitate the configuration of the AudioMoth, recharging of equipment and data transfers between recordings. We also suggest longer project durations, widening engagement to include hobby ornithologists and similar groups who have already some alignments with the topic or experience with citizen-science engagement, as well as gamification options and incentivisation (Howard et al. 2022; KC and Sapkota 2025).

The scope of our study was not designed to evaluate species-specific impacts (due to small sample size). We therefore explored the broader ecological impacts of these invasive evergreen species. Future work could benefit from a focused comparison of these two invasive species, particularly in terms of their differential impacts on biodiversity. Similarly, surveying throughout the year could provide additional insights into seasonal dynamics and further refine our understanding of the ecological impacts of these invasive species. Moreover, while the relatively small number and size of the plots used in this study may limit broader generalisability, the consistent patterns observed across these plots nonetheless provide meaningful insights. Future studies with a larger sample size and more extensive spatial coverage would be beneficial to further substantiate these findings and ensure robustness across different habitats.

Conclusions

This pilot study shows that bioacoustic monitoring is an effective tool for investigating invasive species impacts and that it can be integrated with citizen science to assess how invasive evergreen shrubs influence bird communities. We expect this impact to be caused mainly by the dense shrub layer of the two plant species investigated, altering the habitat structure of the invaded woodlands, where few native shrub species would provide similar habitats. Our results add to the growing literature of impacts of *R. ponticum* in Britain and Ireland, as well as providing first documented evidence of similar impacts caused by *P. laurocerasus*. Future work involving larger spatial coverage, longer temporal sampling and standardised site selection will be essential to validate and expand on these preliminary insights.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

Conceptualization: TSJ, KDS. Data curation: OEA, KDS. Formal analysis: OEA. Investigation: OEA. Methodology: OEA. Project administration: TSJ, KDS, OEA. Supervision: KDS. Validation: OEA. Visualization: OEA. Writing - original draft: OEA. Writing - review and editing: OEA, KDS, TSJ.

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Data availability

The audio-recordings are available from the UKCEH Environmental Information Data Centre (https://doi.org/10.5285/7f11ef69-36e6-4e42-b826-f11c158a0845; Dehnen-Schmutz and Adekola (2024)).

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